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Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Part 73 of the	)	
Commission's Rules to Clarify	)	MM Docket No. 93-225
the Definition and Measurement	)	
of Aural Modulation Limits in	)	
the Broadcast Services	)	

COMMENTS OF THE NATIONAL ASSOCIATION OF BROADCASTERS

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EXECUTIVE SUMMARY

The National Association of Broadcasters ("NAB") supports the Commission's inquiry into the definition and measurement of aural modulation limits in the broadcast services. Although this inquiry also seeks comments on AM and TV modulation limits, the Commission appears more interested in the definition and measurement methods for FM signals, due to their complex nature. NAB's comments address the specific issue of FM modulation limits.

NAB believes the Commission's rules on this issue lack sufficient technical clarity. As a result, FM broadcast stations have wide latitude in choosing methods to gauge compliance with the applicable FCC rules. With such generous flexibility, there are (1) risks that unintended interference can be created among FM stations, even though stations may be in substantial compliance with current FCC rules, and (2) potential FCC rule compliance problems created if the monitors used by the licensee disagree with the monitors used by the Commission. A precise definition of the FM modulation limit would better insure control of adjacent channel interference as well as facilitate industry Rule compliance. A technical study on the effects of processed audio program material on interference to FM adjacent channels is necessary in order to determine accurately whether, and to what extent, protection ratios are affected by peak modulation excursions, and importantly, whether there is any merit to proposing a change to the Commission's rules.

The potential of increased interference permitted by vague or imprecise FM modulation limits is of paramount concern to NAB. Without a precise definition of peak excursion duration and intensity, energy is permitted to exist on channels adjacent to a broadcasting FM station. Without researching and understanding whether, and to what extent, adjacent channel energy of differing intensities and duration creates interference for radio listeners, it is impossible to insure that unacceptable interference to other FM stations will not occur.

Secondly, NAB is concerned with potential FCC rules compliance problems created if FCC modulation monitoring methods differ from those of the industry. Different methods can lead to different conclusions which have consequences for broadcasters. FCC modulation monitoring equipment must provide the same indications, under the same circumstances, as the equipment used by broadcasters.

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I. INTRODUCTION AND SUMMARY

The Commission, on its own motion through a Notice of Inquiry ("Notice"),[1] is seeking comments on the current rules and policies that relate to the definition and measurement of aural modulation limits.

In these comments the National Association of Broadcasters ("NAB")[2] is pleased to have the opportunity to discuss the issue of aural modulation limits addressed in the Notice. Although the Notice also seeks comments on AM and TV modulation limits, the Commission appears more interested in the definition and measurement methods for FM signals, due to their complex nature.[3]

As we discuss below, NAB believes the Commission's rules on

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[1] Notice of Inquiry in MM Docket No. 93-225, 8 FCC Rcd 17 (1993)

[2] NAB is a nonprofit, incorporated association of radio and television stations and networks which serves and represents the American broadcast industry.

[3] Id. at 1.

FM modulation limits lack sufficient technical clarity. As a result, FM broadcast stations have wide latitude in choosing methods to gauge compliance with the applicable FCC rules. With such generous flexibility, there are (1) risks that unintended interference can be created among FM stations, even though stations may be in substantial compliance with current FCC rules, and (2) potential FCC rule compliance problems created if the monitors used by the licensee disagree with the monitors used by the Commission. A precise definition of the FM modulation limit[4] would better insure control of adjacent channel interference as well as facilitate industry Rule compliance. A technical study on the effects of processed audio program material on interference to FM adjacent channels is necessary to determine accurately whether, and to what extent, protection ratios are affected by peak modulation excursions, and importantly, whether there is any merit to proposing a change to the Commission's rules.

II. BACKGROUND.

Until 1983, Section 73.332 of the Rules required that manufacturers design FM modulation monitors in accordance with

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[4] The FM broadcast modulation limit ("100 percent modulation") is defined in 47 C.F.R Section 73.310 simply as a frequency deviation of +/-75 kHz. The rules provide no clear guidance whether RF peak excursions, if any, may be allowed to exceed this limit, except that Section 73.1570 appears to permit peak excursions as long as the peaks are not of "frequent reoccurrance." See, infra, pp. 7-10.

certain minimum specifications in order to receive so-called "type approval" for broadcast use. Former Section 73.332 specified the peak response and ballistics of devices used for modulation monitoring.

In a deregulation proceeding,[5] the Commission deleted Section 73.332 of the Rules and deleted the requirement that FM stations use type-approved monitors to measure modulation limits. In effect, by this action, stations are allowed to use any method desired to assure that modulation levels are maintained within specified limits.[6]

However, section 73.1570 simply states that FM modulation levels must be maintained so that "total modulation must not exceed 100 percent on peaks of frequent reoccurrence referenced to 75 kHz deviation."[7] The term "peaks of frequent reoccurrence" is not defined within the Rules. This vague specification of maximum modulation level has led to a variety of modulation monitoring devices with varying peak response characteristics.

Additionally, vague specifications lead to compliance

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[5] Report and Order in BC Docket No. 81-698, 54 RR.2d (1983).

[6] Id. at 7. The Commission stated, "We have decided, therefore, to delete the requirement for type approval and allow broadcasters to use any method to measure aural modulation levels and, if transmitting stereophonic programs, the stereophonic signal parameters."

[7] However, total modulation may be increased if there are additional subcarriers present. For FM stations transmitting stereophonic programming with subcarriers, the total peak modulation may be increased 0.5 percent for each 1.0 percent subcarrier injection modulation. The modulation of the carrier may not exceed 110 percent (82.5 kHz peak deviation). See, 47 C.F.R. § 73.1570(b)(2).

problems when the modulation monitoring equipment used by the FCC does not provide identical indications as the equipment used by broadcasters. The modulation monitoring method used by the Commission's Field Operations Bureau ("FOB) consists of an oscilloscope connected to an FM receiver's discriminator.[8] The oscilloscope is calibrated to display deviation in excess of the legal limit. The majority of FM stations do not use the Commission's method to measure modulation, but instead often employ highly sophisticated modulation monitors. These monitors may not agree with the FCC's method of modulation measurement leading to potential Rule compliance problems for broadcasters. NAB hopes the Commission's Notice will lead to a resolution and clarification of these problems.

III. THE COMMISSION SHOULD CLARIFY EXISTING PEAK MODULATION LIMITS RATHER THAN ADOPTING NEW EMISSION LIMITS.

A. Numerical emission limits do not adequately characterize the time-varying nature of FM broadcast spectral use.

In the Notice, the Commission requests comments on the desirability of adopting new emission limitations for FM broadcast signals. Because of the fundamental, non-linear nature of frequency modulation, empirical measurements are the optimal tool for analyzing the effects of modulation limits on

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[8] Notice at 8.

interference and distortion. Frequency spectrum occupancy (emission) characteristics do not adequately reflect the time-varying nature of FM broadcast signals. Instead of adopting new spectrum emission limits, NAB urges the Commission to address the measurement discrepancy problems which it has identified by adopting rules, based on solid technical data, which clarify the meaning of "peaks of frequent reoccurrence."

Before discussing the merits of specific approaches to limiting modulation to control interference and prevent receiver distortion, it is useful to review some fundamental principles of frequency modulation theory as they apply to FM broadcasting. Perhaps one of the most important principles is that frequency modulation is a nonlinear process. Exact mathematical analysis is not possible for real world audio signals. Instead, approximations are used which conform to empirical observations.

It is important at this point to note the distinction between two different, yet relevant, measures of an FM signal's bandwidth. The first measure, the necessary bandwidth, is the bandwidth which is required to transmit and receive the signal with a minimal amount of distortion. The second measure, the occupied bandwidth, is the bandwidth over which the signal radiates significant energy which can produce interference. The Commission defines occupied bandwidth as the bandwidth which contains 99% of the total energy of the signal.[9]

An approximation of the necessary bandwidth for an FM signal

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[9] 47 C.F.R. § 2.202(a) (1992).

is provided by Carson's rule: $BW \approx 2*(f_m + f_d)$ where f_m is the maximum frequency of the baseband signal and f_d is the peak frequency deviation of the FM signal.[10] For monophonic FM broadcast signals, Carson's rule provides a fairly straightforward approximation: $BW \approx 2*(15 + 75) = 180$ kHz.

However, Carson's rule suffers from a number of shortcomings as an approximation of the occupied bandwidth of an FM broadcast signal. Carson's rule assumes that the baseband signal bandwidth and the deviation level do not vary with time. In actual practice, a substantial amount of program material, such as speech, contains little or no energy near 15 kHz. Additionally, low level program material reduces the deviation from its peak value of 75 kHz. Therefore, in practice, the occupied bandwidth is substantially less than predicted by Carson's rule.

This effect has been reported by the International Radio Consultative Committee (CCIR). CCIR Report 1065 contains measurements of the occupied and necessary bandwidths of FM signals modulated with non-compressed audio program material.[11] Such program material produces deviation levels which are often substantially less than the peak value. According to the above discussion, such programming should yield bandwidths much narrower than predicted by Carson's rule. Indeed, CCIR Report 1065 concludes that "the RF bandwidths of FM sound-broadcast

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[10] K. Sam Shanmugam, Digital and Analog Communication Systems 284 (1979).

[11] Reports of the CCIR, 1990, Annex to Volume X - Part 1, at 121 (Geneva, 1990).

emissions are obviously smaller than one would expect from calculations using Carson's rule."[12]

Therefore the bandwidth of even a simple monophonic FM broadcast signal is a function of the program material and processing used and is not susceptible to exact analysis. The problem becomes more complicated when one considers the case of stereophonic FM broadcasts. For FM stereo broadcast signals, the baseband extends to 53 kHz. Application of Carson's rule yields a necessary bandwidth of 256 kHz. The Commission's rules provide 240 kHz of bandwidth for FM broadcast signals.[13] In practice, the occupied bandwidths of FM stereo broadcast signals are typically less than 200 kHz, depending upon the program material being broadcast and the audio processing used.[14]

The presence of subcarriers complicates the picture further. The important point is that meaningful analysis of the emission characteristics of FM broadcast signals is difficult if not impossible without resorting to empirical measurements. The usual difficulties of analyzing non-linear frequency modulation are compounded by the complex nature of the processed, compressed, stereo modulating signal and additional subcarriers that may be present.

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[12] Id. at 126.

[13] 47 C.F.R. § 73.317 (1992).

[14] See Rau et al., The Effects of Increased Deviation on Adjacent FM Channel Protection, PROCEEDINGS OF THE 38TH ANNUAL BROADCAST ENGINEERING CONFERENCE 193, 203 (1984).

B. The Commission should clarify peak modulation limits rather than adopt new emission limits for resolving discrepancies in the measurement of modulation bursts.

This Notice examines the effects of occasional peaks of short duration on adjacent channel interference and receiver distortion. The Notice states that "the marketing of monitors which give different indications is the catalyst for this reexamination of modulation measurement."[15] Modulation peaks reflect a time-variant aspect of an FM broadcast signal. In a precise mathematical sense, measurement of the frequency spectrum of an FM signal requires integration over a very long period of time. In practice, the frequency spectrum which is measured varies substantially depending upon the length of time over which the signal is observed and the program material used. Over the long observation periods necessary to make an accurate measurement of an FM signal's spectrum, the effects of infrequent high modulation peaks become obscured.

The Commission has identified a problem involving discrepancies in the way different devices measure modulation levels. These discrepancies occur because of the way different devices measure modulation peaks which occur infrequently and for brief periods of time. The Commission's emission limits control the long term spectral occupancy of the FM signal, but do not effectively control brief, occasional, bursts of high modulation. For these reasons, NAB believes that the adoption of new emission

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[15] Notice at 2.

limits is an inappropriate approach to addressing the measurement discrepancies which the Commission have identified.

Moreover, it is doubtful that comprehensive new emission limits could be developed which would not either substantially increase the amount of allowable interference, or unnecessarily restrict the continued use of existing processing practices which are not generating harmful interference. As the Commission notes in the Notice of Inquiry, FM multiplexed signals are much more complex than the signals transmitted in the land mobile service.[16] For the land mobile service, where the modulating signals tend to be uniform, the combination of emission limits with baseband filtering is an effective means of controlling interference. In contrast, the spectrum characteristics of FM broadcast signals vary widely because of differences in program material, audio processing, and subcarrier usage. The Commission has recognized that the interference potential of an FM signal depends upon the content of its modulating signal (e.g., the presence of subcarriers).[17] It is not clear whether new restrictive emission limits could be developed which reflect the interference potential of the wide variety of FM broadcast signal characteristics.

C. Adoption of new emission limits would pose new issues.

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[16] Notice at 4.

[17] See 47 C.F.R. § 73.1570(b)(2)(i)-(ii) (1992).

Meanwhile, adoption of new emission limits to control interference presents its own set of measurement issues. The Commission may have to specify the resolution bandwidth, sweep period, and observation interval for measuring the spectrum of the broadcast signal. Determination of appropriate values for these parameters involves the resolution of questions which are similar to those posed in the measurement of brief modulation peaks. Thus the adoption of new emission limits would not alleviate the need for adopting rules which effectively control harmful interference and produce consistent measurement results.

Instead of attempting a major overhaul of the rules which control interference for FM broadcast signals, NAB believes that the Commission should focus on the more narrow issue of how to clarify the existing rule which limits peak modulation levels. The Notice of Inquiry states that "the marketing of monitors which give different indications is the catalyst for this reexamination of modulation measurement."[18] In fact, these devices give different indications because of differing opinions by manufacturers over what is required for compliance with the existing modulation rules.

The existing rule, based on limiting "peaks of frequent reoccurrence,"[19] is susceptible to a variety of interpretations. NAB urges the Commission to adopt rules which clarify the meaning of "peaks of frequent reoccurrence," rather than crafting new

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[18] Notice at 2.

[19] 47 C.F.R. § 73.1570(b)(2) (1992).

emission limits.

IV. ANY NEW MODULATION LIMITS MUST HAVE A SOUND TECHNICAL BASIS, PROVIDE COMPLIANCE CERTAINTY, AND REFLECT PREVAILING PRACTICES.

The Commission initiated this proceeding, in part, due to the marketing of monitors which may give different indications of a particular modulation measurement.[20] Some monitors are designed in accordance with the specifications set forth in Section 73.332 of the rules (prior to 1983).[21] Other monitors are designed following the guidelines in former Section 73.342 of the rules, which defined allowable modulation tolerances for automatic transmission systems.[22]

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[20] It is interesting to note that during the comment cycle for BC Docket No. 81-698, some comments indicated that elimination of the type approval requirement would result in the marketing of monitors with varying measurement accuracies. In the resulting Report and Order, the Commission stated it believed "...that this concern with accuracy is overstated." Indeed, monitors are now being marketed with varying measurement accuracies, since precise technical specifications for monitors were eliminated from the rules as a direct result of 81-698. The rule changes affected in 81-698 were crafted to "...take the Commission out of the business of specifying operational and equipment characteristics of modulation monitors and of testing the monitors to insure compliance with those requirements."(Notice of Proposed Rule Making in BC Docket No. 81-698, 46 Fed. Reg. 59328 (1981)).

[21] See, e.g. 47 C.F.R § 73.332, October 1, 1981. Precise technical specifications were defined for monitor peak indicators. "The peak preset indicator must also respond correctly to tone bursts at repetition rates from one to ten bursts per second with the following composition of the bursts: (i) Ten consecutive cycles of a constant amplitude 10,000 Hz sinusoid; and (ii) five consecutive cycles of a constant amplitude 1000 Hz sinusoid. In addition, each response of the peak preset indicator shall persist for a minimum of 2 and a maximum of 4 seconds and be independent of the direction of frequency deviation." 47 C.F.R. § 73.332(d)(4).

[22] Former 47 C.F.R § 73.342 defined the specifications for automatic transmission systems. Part of the automatic transmission system requirements were stated in § 73.342(b)(3): "The transmitting system must have a device

Most recently, monitors are being designed that can be adjusted to respond to, or ignore, modulation peaks of different intensities and durations.[23] These types of monitors can be adjusted to give different indications of the modulation level for the same transmissions.

It is the common practice of FM stations to use varying amounts of audio processing depending upon programming format. For instance, stations with "rock" formats tend to use far more audio processing than stations with "classical" formats. In order to preserve musical dynamic range, some stations prefer to use very little audio processing. Other stations prefer very aggressive audio processing with very tight control of audio peak-to-average ratio.

One problem that concerns broadcasters is the dramatic variance in perceived loudness among stations. Typically, soft music with light processing contains less average energy than rock music with aggressive processing. Higher average audio evergy level equates to greater perceived loudness. Since brief audio peaks contribute very little to loudness, monitors that respond to very short duration peaks, by design not only do an

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that will detect and adjust the peak level of modulation. If the modulation exceeds more than 10 bursts of 100 percent modulation within a one minute period as measured at the output terminals of the transmitter, the program audio input signal to the transmitter modulators shall be automatically adjusted downward until these limits are not exceeded. For the purposes of this requirement, a sequence of repetitive instances of modulation exceeding the prescribed limits occurring within a single 5 millisecond interval will be considered to be one burst."

23 Notice at 5.

excellent job of controlling overmodulation, but also maintain the loudness differential between stations of differing program formats.

Stations have discovered that monitors with adjustable peak response can be set to respond only to relatively long duration peaks -- ignoring short duration peak bursts. By using these types of monitors, stations with classical or other "light" programming may increase their modulation levels and consequently be more competitive on the loudness scale with stations using greater amounts of audio processing.

On the surface, the practice of monitoring modulation limits using adjustable peak response devices seems to be ideal from the standpoint of allowing stations that desire to use less audio processing, or have soft music formats, to be more competitive with other stations in noisy environments, such as the typical automobile. However, NAB is unaware of any studies that have been performed to ascertain the effects of varying degrees of peak excursions, created by processed program material on FM adjacent channel interference levels. Intuitively, the higher the modulation peak level the greater the interference to adjacent channels, with longer duration peaks more likely to cause interference than short duration peaks.

If we assume that certain brief peaks should be allowed to exceed +/-75 kHz on occasion, the Commission must (1) understand the effects of the peak excursions on FM adjacent channel interference levels and (2) define a specific response time for

the peaks based upon their interference impact.

Without knowing the effects of varying degrees of peak bursts that exceed +/-75 kHz, it is not possible to insure that unacceptable interference to other FM stations will not occur.

V. THOROUGH TECHNICAL STUDIES ARE NEEDED BEFORE ANY NEW RULES CAN BE PROPOSED CONCERNING FM MODULATION LIMITS.

Before any new rules can be proposed concerning FM modulation limits, additional technical data is needed. At this time, NAB is inclined to support the need for monitors with adjustable peak response times. This appears to be a fair and effective method for stations desiring to use lesser amounts of audio processing to be competitive (with respect to loudness) with stations using greater amounts of audio processing. However, NAB has long been a champion of preserving the technical integrity of the broadcast service by opposing any proposals that could lead to increased interference among stations.

Additional technical data about the effects of peak intensity and duration on first, second and third adjacent channel interference should be gathered to support any proposed rule making. Data on reception effects should be accumulated on a variety of typical FM radios, ranging from low cost to expensive, portable, automotive and home types.

Several "program-like" test signals have been used for

various past interference studies.[24] Careful attention must be given to the selection of the test signal to insure that (1) it accurately mimics processed audio and (2) it can be easily duplicated (in order to yield consistent, repeatable test results).

The technical data gathered during such an analysis may then be used to create a model, defining the modulation limit, by which proposed rules could be crafted.

VI. CONCLUSION.

The Commission has raised myriad questions in the Notice. Most of the questions relate to peak modulation excursions and how these excursions should be defined and subsequently monitored. We have offered comments on this specific issue and

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[24] Some "program-like" test signals that have been used in the past include CCIR standardized coloured noise (described in Recommendation 559), USASI noise and pulsed USASI noise. A further test signal defined as "Synthetic Program Noise," is described in "Increased FM Deviation, Additional Subcarriers and FM Broadcasting: A Technical Report," NAB, Westinghouse Broadcasting and Cable, Inc., National Public Radio, August 30, 1983 (entered into BC Docket No. 82-536).

must urge the Commission not to proceed with any proposed rule making until sufficient scientific data is available to determine the effects of modulation excursions on adjacent channel interference. Only then should the Commission again move forward with this proceeding.

Respectfully submitted,

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